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THE NEED OF ELEMENTARY MATHEMATICS

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The ordinary course of study in elementary mathematics is commonly stated not so much with reference to what we are to do as with reference to what we are to accomplish. It sets forth an aim and leaves to the teacher, or to the writer of the textbook, the choice of the means. Now, with a subject-matter selected and organized in the interest of the child we have the conditions of growth, the factors which cause him to exert himself to the best of his ability; but, on the other hand, if there is no such relation between him and the subject-matter, then he can have no internal, or intrinsic, motive in his work, and all genuine effort on his part will become stifled. So we see how much depends on a proper choice of material. We hear so much of the distaste children acquire during their school life for the study of mathematics. Can it be that the material of instruction is not properly adjusted to their needs and life-interests?

The scope of this inquiry is rather large, embracing, as it does, a course of study extending over eight years. Hence, it is hardly feasible to give a general answer. Besides, whatever may need to be said about one part of the course does not necessarily apply with equal force to another. So, for convenience, we will divide the subject of discussion into the following subdivisions:

1. Kindergarten and Grade 1: the teaching of the number-concept.

2. Grades 2, 3, 4, and 5: the teaching of the operations with numbers, both integral and fractional.

3. Grades 6, 7, and 8: (a) the applications of number in trade and business; (b) laying the foundation for algebra and geometry.

1. *The teaching of the number-concept.*—The first lessons in arithmetic, which involve counting and measuring, have for

their immediate purpose the development of the number-concept. We wish the children to form an idea of number as a discriminant of relation. However, exercises in mere counting and measuring are not of themselves sufficient for this purpose. A boy may be asked to count the spools on a table, and he will gladly enough respond to the task. But ask him to count the apples in a basket which his mother has just brought home, and he will do that more eagerly, probably also more accurately, because in this he has a personal interest, while in the former he had none. He perceives the number of apples in relation to something else—his appetite, for instance—and is thus led from one problem to another, the division of the number of apples into parts.

We may judge from this illustration that our general purpose, the development of the number-concept, will be served best, if we can arrange the work so as to fit in with some thought which the children are carrying on of their own initiative, or with some problem arising out of their plays and occupations.

Briefly stated:

a) Every exercise should be a real problem for the child so as to fully engage his attention.

b) It should give him something to do which will incidentally necessitate measuring and counting.

c) It should lead him on to a new problem.

Naturally, the task of choosing suitable exercises is no light one. In fact, it demands the most careful thought and study on the part of the teacher. There are no textbooks to help him. He must explore for himself the particular sphere of interest of the children under his care, join in their plays and occupations, and derive from these a series of problems related to their life-interests and needs. These problems should involve exercises in constructive activity, and present the conditions which will make it necessary for the child to count and measure, repeated processes of this kind leading him to a correct appreciation of the relations, "more or less," "greater or smaller," etc., and involving the fundamental ideas of addition, subtraction, multiplication, and division.

2. *The teaching of the operations with number.*—While

counting and measuring so as to learn that number is not a property of objects, the child unconsciously acquires some knowledge of the fundamental operations, though only within a small number limit. When he passes into the second grade, this limit is gradually enlarged, the complete mastery of the fundamental operations, both with integral and fractional numbers, by the time he finishes the fifth, becoming the objective point of instruction. It is here that drill is especially in place; but it is here also that mere figuring is likely to be overdone, and becomes tedious and destructive of interest, tending to make of the pupil a mere calculating machine.

Glancing over the history of mathematical teaching, we find that the remedy for this has been sought and found in the use of concrete problems, both in the beginning and in the end. These are made to serve (1) as a basis for the unfolding and learning of the processes, and (2) as a means for the application of the principles taught.

The first phase of the use of concrete problems has been worked out very well and to general satisfaction. No teacher nowadays attempts to teach, e. g., 6 divided by $\frac{1}{2}$ without offering it first in some such form as "How many half-dollars will pay a debt of six dollars?" The pupil is given an opportunity to visualize the process. Conditions are provided which stimulate his self-activity and lead him to arrive at a solution *quasi* through his own effort. Another problem or two from the pupil's little world of trivial relations, offering like opportunities for visualization, and the pupil is ready to generalize that all 6's divided by $\frac{1}{2}$ give the same result. When a process is thus developed, work with pure numbers, with these concrete problems as a dim background, will then have a distinct value as drill in fixing it permanently.

We have not been so fortunate with regard to the second phase of the use of concrete problems. For that has been only partially developed. We have come to see that the educative element in mathematics does not lie so much in gaining accuracy and rapidity with figures as in acquiring the power to discern which operation to use in a given case, and we have accordingly given up

the grouping of problems under "cases" so characteristic of the old textbooks. However, our modern texts are yet by no means satisfactory. Instead of the old-time formal connection between the problems, objectionable though it was, we now have no connection at all, either in form or context. The books remind one more of a speller than a reader. You may select almost any two consecutive problems, and you will hardly find any connection between them in thought or in points of interest to a child. It is true, the pupil has to decide for himself what processes to use in the solution. He is certainly not robbed of the opportunity to think. But as to his motive for doing this work, is the desire "to figure" sufficient to sustain his interest?

It seems to me that these "applications" should be arranged in some order, in groups, so that each group follows up some central idea growing out of the environment of the child, leading out from some of his experiences, and teaching him something new and worth knowing. There are a good many interesting relations in the child's immediate environment about which he wants to know, and which the use of numbers may help to explain.

Problems selected along these lines would surely engage and hold the interest of the pupils, besides awakening in them a sense of the usefulness of arithmetic as a tool in dealing with the ordinary affairs of life. The purposelessness of figuring would disappear along with the distaste for it. There would also be ample opportunity for the exercise of the power of analysis before mentioned; and since the pupil's interest is bound up in his work, he will come to appreciate this power of his own accord.

3a. *The applications of number in trade and business.*—When the child passes into the sixth grade, it is presumed that he knows the fundamental processes, and hereafter his work is directed toward broadening and deepening this knowledge. In the selection of material, the time-honored custom of giving business subjects a prominent place still prevails; and there is no doubt that this choice is also in accord with a popular demand. Indeed, everyone who would be a useful member of society wants to form an intelligent acquaintance with them.

The difficulty usually encountered in teaching these subjects hinges on the point of departure. Textbooks start each topic with a lot of definitions of terms and relations unfamiliar to the child, and often also to the teacher. Then follow the problems without sequence of thought, that is, such a sequence as would unfold the subject. They lack the connection with the actual experiences of the children which would make them real problems for them and engage their interest. The much-lamented failure of our boys and girls to make any headway with commission, exchange, or taxes is largely due to this lack of interest on their part. It is because they see no relation to any problem of their own.

The average child knows very little about these subjects. Is it probable that a few definitions, no matter how well they may be put, however simple the language, can supply this deficiency? Is there no better way? Take, for example, the subject of taxes. Can we not find in the child's previous experience a problem that presents ideas akin to those of taxation, from which we may gradually—by linking problem to problem—develop the whole subject in all its aspects?

SUGGESTION OF A PLAN TO TEACH TAXES

I. Connection with the experience of the child. Problems involving the ideas of assessment, levy, and tax.

a) The pupils of a school consisting of 4 rooms, numbering 27, 48, 30, and 55, respectively, wish to buy a picture valued at \$8. What is the best and fairest way of raising the money? (Chance to define "assessment.")

b) Four newsboys in the business district clubbed together to "run a newstand," agreeing to take turns in attending to the business and to share the expenses according to their respective earnings. They earned \$30, \$10, \$20, and \$40, respectively; the expenses were \$20. How much should each pay?

II. Discussion of some civic function familiar to children, such as street-lighting, street-cleaning, police and fire protection, maintenance of schools, etc.

Questions: (1) Why does not every citizen light the streets

surrounding his property, maintain a school for his children, etc.? (Show that it is cheaper and better for him to divide the expense with others and obligate himself to pay his share, called "tax.") (2) Who pays the policeman and the fireman? (3) How is the money obtained?

III. Development of idea of "tax-rate." Problems: Supposing the 5,000 inhabitants of a certain town want to raise \$50,000 to equip a fire department. How should this money be raised? (Emphasize the equity of determining the tax in accordance with property values.) If the estimated (assessed) value of property in this town is \$2,000,000, how much should be paid on property valued at \$10,000, \$575, \$7,987, \$15,750, respectively? What is the best way of figuring on this? (Show that it is best to find the rate per \$1 valuation. This is called the "tax-rate." In this case it is $2\frac{1}{2}$ cents on the \$1 valuation, or 25 mills, as it is usually expressed.)

IVa). The necessity of employing assessors and tax-collectors as public officials. (Different kinds of taxes: city, county, and state; tediousness of the work; use of "tax-table" to lighten the work of computing amounts.)

b) The tax-bill. Practical problems involving the use of the forms.

c) Why should tax-bills be paid promptly and cheerfully? (Penalty.) Problems.

V. Support of the federal government. Questions: (1) Who pays the postman, the weatherman, the army, etc.? (2) What is meant by internal revenue, tariff, duty? How are these regulated? How collected? (3) What is meant by "smuggling"? (Give a table of customs duties; free-list.) Problems.

3b) *Laying the foundation for algebra and geometry.*—Practice and drill in the principles of arithmetic is only part of the work in the upper grammar grades, for the course of study embraces also the rudiments of algebra and geometry. Added to the curriculum within the last twenty years in response to the demand for its enrichment, these subjects have not yet become thoroughly established, nor is there a sufficiently definite understanding as to the proper mode of presenting them. This is

especially true of geometry. Its specialized treatment in the high school, questionable even there, though probably the only treatment known to many of the grade teachers, has been discarded as beyond the capacity of the pupils. However, in trying to refrain from giving and requiring formal proofs, we have drifted into the other extreme, the method of telling or "dictation." Think of giving, in the eighth grade, minute instructions for the drawing of a circle with the compasses even to the placing of the points, when a few well-directed questions would elicit the necessary information from the pupil! Yet courses of study and textbooks prescribe "dictation" as the method of teaching all the fundamental problems of constructive geometry. Is not the act of acquiring knowledge worth more to the child than the knowledge itself? There is nothing for him to do when the material is given him in ready-made form, except to absorb, and memorize, it in its logical wrappings. As in all education, so here

the process of self-development should be encouraged to the uttermost. . . . Children should be told as little as possible. . . . Any piece of knowledge which the pupil has himself acquired, any problem which he has himself solved, becomes by virtue of the conquest much more thoroughly his than it could else be.¹

Both algebra and geometry have side-lights in the life-interests of the children which furnish excellent supports to the study of these subjects, points to start from, as well as factors in sustaining an active and progressive interest. So there is no reason why the proper conditions may not be presented which will enable pupils to work out every one of those problems, seeking and finding the reasons for the steps in terms of their previously acquired experiences.

Education is the interaction of the old experience with a new experience felt as valuable. It presumes that the principle of self-activity is basic, inasmuch as the best results in teaching are gained when the child becomes active through a desire to solve a problem growing out of his needs and interests. We have pointed out in the foregoing that this thought has been given too

¹ Spencer, *Education*.

little attention in the construction of our courses of study and the textbooks in use. May we not conclude, for that reason, that both are in urgent need of revision? We have also recognized the desirability and possibility of grouping problems around some central thought emanating from the child's environment, and teaching him something besides mere figuring. There are many subjects scattered over the program which are available for this purpose. May we not relieve the crowded condition of the curriculum by taking these up during the time given to mathematics? We are breaking away from conventional lines in other subjects. Why not in mathematics?